MECHATRONICS BOOK SERIES
SELECTED PAPERS FROM ICOM'01, ICOM'05 AND ICOM'08

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IIUM Pres

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN: 978-967-0225-68-5

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN. BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

CONTENTS

CHAPTER ONE: Mechatronics System Design and Applications

CHAPTER TWO: Modelling and Simulation

CHAPTER THREE: Intelligent Systems

CHAPTER FOUR: Instrumentation, Dynamics and Control

CHAPTER SIX: Speech and Image processing

CHAPTER SEVEN: Robotics and Automation

CHAPTER EIGHT: MEMS and Materials

CHAPTER NINE: MEMS and Materials

CHAPTER TEN: MEMS and Materials

CHAPTER ELEVEN: MEMS and Materials

Selection of Materials and Design Specification for Hip Joint Prosthesis

I. Sopyan,[1] E. Haruman,[1] A.G.E. Sutjipto,[1] and R. Muhida[2]

[1]*Department of Manufacturing and Materials Engineering.*
[2]*Department of Mechatronics Engineering.*
Faculty of Engineering, International Islamic University Malaysia (IIUM)
Jalan Gombak 53100, Kuala Lumpur, Malaysia
Ph. +60-320564592; Facs. +60-320564477; e-mail: sopyan@iiu.edu.my

ABSTRACT

The hip is essentially a ball and socket joint, linking the "ball" at the head of the thigh bone (femur) with the cup-shaped "socket" in the pelvic bone. A total hip prosthesis is surgically implanted to replace the damaged bone within the hip joint. Basically, the hip joint prosthesis consists of three parts: (1) acetabular cup that replaces hip socket, (2) a metal or ceramic ball that will replace the fractured head of the femur and (3) a metal stem that is attached to the shaft of the bone to add stability to the prosthesis. Parameters determining the performance of the total hip joint replacement are materials, design, and fixation method. The materials used in a hip replacement are designed to enable the mechanical joint to move just like a normal joint. The prosthesis is composed of several types of metal and durable plastic. One of the inherent problems in hip joint prosthesis implantation is the fixation and maintenance of a stable interface between the device and the host tissue at the cellular and organ levels. Although evaluation of success or failure of the prosthesis fixation could be quite difficult clinically, proper material design will minimize potential problems probably appearing after implantation. Recent progress on materials design and development for this application will be presented.

1. INTRODUCTION

1.1. Human Bones and Hip Joints

Bones are calcified connective tissue forming the major portion of the skeleton of most vertebrates. They contain more calcium than any other organ. Bone is composed of inorganic and organic materials in dynamic equilibrium with the body fluids. Although the proportions vary from one part of the skeleton to another, water-free bone contains about 70% inorganic and 30% organic materials. The inorganic phase consists of calcium phosphate-based ceramics, primarily hydroxyapatite crystals; it is hard and brittle and represents the main load-bearing component of the bone structure. The organic phase, primarily collagen fibers, is gelatine-like protein and its presence makes the bone tough, in addition to its biological functions [1]. These phases are generally arranged in a complex structure to give maximum strength in the required direction.

When two or more bones meet each other they form joints. Joints make the skeleton flexible. Without them, movement would be impossible. The human hip joint consists of a ball *(femoral head)* at the top of our thighbone *(femur)* that fits into a rounded socket *(acetabulum)* in our pelvis. Typical construction of the ball and the socket allows for movement in almost all directions. A simple illustration of the human hip joint is presented in Figure 1. The femur is the bone of the upper leg,